7 RISK ASSESSMENT & DISASTER MANAGEMENT PLAN

7.1 BACKGROUND

Risk Assessment is a management tool for determining the hazards and risk associated with the various activities of a project and compute the damage potential of these hazards to life and property. Risk Assessment provides basis for determining the safety measures required to eliminate, minimize and control the risks as detailed in Disaster Management Plan (DMP) to handle onsite and offsite emergencies.

In Chemical Industry, Risk Assessment is carried out for the various hazards involved in storage and handling of hazardous raw materials, intermediates and finished products as well as for the manufacturing processes used by the unit.

7.2 OBJECTIVES

The given study was focused to fulfill the following objectives:

- Identification of safety areas
- Identification of process and storage hazards
- Visualization of maximum credible accident (MCA) scenarios
- Consequence analysis of scenarios
- Determination of quantities released, impact zones
- Estimation of damage distances for the accidental release scenarios with recourse to Maximum Credible Accident (MCA) analysis
- Preventive and control measures required for reducing the risk factors
- Delineation of Disaster Management Plan

7.3 SCOPE OF WORK

Based on the objectives as defined above, the scope of work for the given study has been framed as under:

- Hazard Identification
  - ✓ General description of project
  - ✓ Study of manufacturing activities
  - ✓ Study of plant facilities and layout
  - ✓ Hazardous inventory
  - ✓ Associated process and storage hazards
  - ✓ Safety measures as proposed by the proponent
- Hazard Assessment
- Identification of MCA and worst case scenarios using standard techniques
- Consequence analysis of selected scenarios using EFFECT model on ALOHA software
- Determination of risk reduction measures
- Preparation of DMP
- Recommendations

7.4 METHODOLOGY

- Collecting Input data about Process, Inventories and Site conditions
- Hazard Identification
- Defining the Potential Accident Scenarios
- Evaluation of Consequences and Estimation of Accident Frequencies
- Estimate the Impacts
- Estimate the Risk
- Identify and Prioritize the Risk Reduction measures.

The guidelines given by SEAC as well as Technical Guidance Manual of MoEF&CC have also been followed.

7.5 HAZARD IDENTIFICATION

This is important and critical step in risk assessment. It is critical because Hazard omitted is hazard not analyzed.
The unit shall handle hazardous materials and shall have a defined and organized hazard control and prevention system in place. The following statutory compliances shall be applicable to the unit :

- The Factories Act 1948 & Rules therein
- Gujarat Factories Rules, 1963
- Manufacture Storage and Import of hazardous chemicals Rules, 1989, amended 2000
- Petroleum Act, 1934, Petroleum Rules, 2002
- The Gas Cylinder Rules, 2016 and its amendment thereafter
- Chemical Accidents (Emergency planning, Preparedness and Response) Rules, 1996
- The Insecticides Act, 1968 and Rules 1971
- The Static and Mobile Pressure Vessels (Unfired) Rules, 2016

The hazards of the materials are identified from the MSDS. The major hazards are toxic, fire and explosion. Flammable material will form pool on leakage and this pool can sustain a pool fire. In case of toxic material the vapors evaporated from pool disperse in downstream direction and may cause problem for people in process units / buildings.

Proponent has classified hazardous incidents into three levels in onsite emergency plan:
(a) Level 1: This is an emergency or an incident which
(i) Can be effectively and safely managed and contained within the site, location or installation by the available resources;
(ii) Has no impact outside the site, location or installation.
(b) Level 2: This is an emergency or an incident which
(i)Cannot be effectively and safely managed or contained at the location or installation by available resource and additional support is alerted or required;
(ii)Is having or has the potential to have an effect beyond the site, location or installation and where external support of mutual aid partner may be involved;
(iii)Is likely to be danger to life, the environment or to industrial assets or reputation.
(c) Level 3: This is an emergency or an incident with off-site impact which could be catastrophic and is likely to affect thepopulation, property and environment inside and outside the installation, and management and control is done by district administration. Although the Level-III emergency falls under the purview of District Authority but till they step in, it should be responsibility of the unit to manage the emergency.

Note: Level-I and Level- II shall normally be grouped as onsite emergency and Level- III as off- site emergency.

7.6 STORAGE HAZARDS AND CONTROL MEASURES

Hazardous chemical inventory is given at chapter 2, section 2.9.2.
Organic and inorganic chemicals in the form of liquids, solids as well as compressed gases are handled in the unit. Details of product - wise consumption is given as Annexure – 24.
All chemicals are stored and handled in accordance with Material Safety Datasheet. MSDS of few chemicals are annexed as Annexure – 33.
Hazardous properties are tabulated in Annexure-26. It should be noted that not all inventory shall be made at a time at site. These materials shall be procured and stored at the site according to requirement of production schedule.

Storage hazards are identified and delineated in onsite emergency plan. Required preventive and control measures are evaluated using safety studies such as HAZOP and verified through regular inspection and safety audits. Standard Operating Procedures (SOPs) are formulated for storage, loading and unloading, handling of hazardous chemicals as well as handling of drums and cylinders, spill control as well as emergency response. Workers are trained to follow SOPs. List of SOPs is given in Chapter 10 of this report.

Chemicals covered under Static & Mobile Pressure Vessels (Unfired) Rules, 2016 & Petroleum Act, 1934
BRL-D has license and approvals from CCOE (PESO) for bulk storage of Petroleum Class chemicals under Petroleum Act, 1934 and amendments therein and Flammable gases under the Static & Mobile Pressure Vessels (Unfired) Rules, 2016. Copy of license is annexed as Annexure-14.
Necessary license shall be obtained for new storages for proposed expansion.

Chemicals covered under Gas Cylinder Rules, 2016 and its amendment thereafter and rules therein
Presently the unit is an MAH installation in accordance to the schedule 3 of MSIHC rules, 2000 and amendments therein for chlorine storage and there shall be no change in chlorine storage and MAH installation status after proposed expansion. Copy of license is annexed as Annexure-14. Proponent shall obtain necessary license for cylinder storages for proposed expansion

Major hazardous storages in the unit

Sr. No.	Name of the hazardous substance	Quantity		Place of its storage	State & operating pressure & Temperature	Type of Hazards	Control Measures provided
		Maximum that can be stored	Actually stored				
1	H2SO4 (98%)	25 MT	20 MT	Tank Farm	Atm Press. & Ambient Temp.	Corrosive	Restricted Entry, dyke, Periodic maintenance
2	HCl (30%)	25 MT	20 MT	Tank Farm	Atm Press. & Ambient Temp.	Toxic	Restricted Entry, dyke, Periodic maintenance
3	Phenol	45 MT	40 MT	Tank Farm	Atm Press. & Ambient Temp.	Corrosive	Restricted Entry, dyke, Periodic maintenance
4	Bromine	10 MT	8 MT	Tank Farm	Atm Press. & Ambient Temp.	Toxic	Restricted Entry, Hood with Scrubber
5	H2 trolly	870M3	870M3	Ground Floor near Hydrogenation Plant	incoming pressure 150 kg/cm2 and outgoing pressure 10 kg/cm2	Fire & Explosion	Sensor, alarm & trip, automation
6	Hexane	25MT	6 MT	Under Ground Solvent Tankfarm	Atm Press. & Ambient Temp.	Fire & Explosion	Underground tank, restricted area, earthing & bonding, flame arrestor, Fire fighting facility
7	Toluene	25MT	2 MT	Under Ground Solvent Tankfarm	Atm Press. & Ambient Temp.	Fire & Explosion	Underground tank, restricted area, earthing & bonding, flame arrestor, Fire fighting facility
8	EDC	40MT	5 MT	Tank Farm	Atm Press. & Ambient Temp.	Fire & Explosion	??
9	DMA 99%	3MT	3 MT	Flammable Tank Farm	3.5 kg/cm2 presssure	Fire & Explosion	Restricted area, Sensor, alarm & trip, automation, Safety Valve, Sprinkler system, fire hydrant system
10	Isobutylene	40MT	40MT	Flammable Tank Farm-2	1.8 kg/cm2 presssure	Fire & Explosion	Restricted area, Sensor, alarm & trip, automation, Safety Valve, Sprinkler system, fire hydrant system
11	Acronitrile	10MT	10MT	Plant C tank Farm	Atm Press. & Ambient Temp	Fire & Explosion	Restricted area, Sensor, alarm & trip, automation, Safety Valve, Sprinkler system, fire hydrant system
10	DMS 98%	0.750 MT	1 MT	Plant C- 1st floor	Atm Press. & Ambient	Toxic & Flammable	Scrubbing system

11	Benzene	25 MT	17 MT	Under Ground Solvent Tankfarm	Atm Press. & Ambient Temp.	Toxic&Flammable	Underground tank, restricted area, earthing & bonding, flame arrestor, Fire fighting facility
12	Caustic Soda NaOH	46 MT	46 MT	Tank Farm	Atm Press. & Ambient Temp.	Corrosive	
13	Chlorine	18 MT	18 MT	Tonner	5 kg/cm2 pressure	Toxic	Storage under shed, hood with scrubber, SCBA
14	Mono Ethylene Glycol (MEG)	17.6 MT	17.6 MT	Storage tank	Atm Press. & Ambient Temp.	Flammable	Restricted Entry , dyke, periodic maintenance
15	Isopropyl Alchohol	16 MT	16 MT	Under Ground Solvent Tankfarm	Atm Press. & Ambient Temp.	Flammable	Underground tank, restricted area, earthing & bonding, flame arrestor, Fire fighting facility
16	Methanol	30 MT	30 MT	Under Ground Solvent Tankfarm	Atm Press. & Ambient Temp.	Toxic & Flammable	Underground tank, restricted area, earthing & bonding, flame arrestor, Fire fighting facility
17	Thionyl Chloride	15 MT	15 MT	Tank Farm	Atm Press. & Ambient Temp.	Toxic	Restricted Entry , dyke, periodic maintenance

7.7 PROCESS HAZARDS AND THEIR CONTROL MEASURES

Table 7-1 Process Hazards and their Control Measures

Sr. No.	Cause	Reason	Type of Hazards possible	Probability / Severity	Preventive Measures provided	Control Measures provided
1.	Leakage from line / valve	Failure of valve or joints	Chemical Spill, Toxic Release, Fire Explosion	Low /Medium	• PLC / DCS control for hazardous processing operations • Instrumentation for process operations • All lines / valves periodically checked, • preventive maintenance of all safety devices • PSVs on pressure lines • Operators trained for the process and SOPs • PPE provided to workers • Spill kits • Flameproof fittings are provided.	Fire hydrant system, Fire Extinguisher, Sand buckets, First-aid and Medical facilities LEL Sensors for early detection
2.	Failure of part of vessel or jacket	Overpressure and failure of safety device				
3.	Spillage from drums / bags	Manual error, rupture				

7.8 OTHER HAZARDS & CONTROL

Following are the other possible hazards:

1. Mechanical hazards- Rotating Equipments viz. Agitator drives, pumps – accidental entanglement of clothes or body touch, Hand Tools and portable power tools – hit or fall on body part due to mis-operation or sudden startup or manual error, electrical shock - Guards shall be provided on all rotating equipment. The hand tools

shall be kept at specified location so that they are easily available when required. Scaffolding and fall protection for working at height, Periodic inspection of lifting tools and tackles, inspection of pressure vessels, SOPs, Work permit system, HSE guidelines in place and regularly refreshed by HSE trainings

2. Electrical hazards - Electrical shock proof gloves and shoes, Electrification as per zone classification, Electrical work permit system, Proper earthing shall be provided to all electrical equipment and checked regularly. Operators shall be educated and trained for protection against electrical hazards.
3. Structural failure – this hazard is related to other hazards
4. Transportation hazards - proponent has taken adequate fire protection and control measures for inplant and parked transportation as mentioned in later sections.
5. Toxic Release from outside – taken care by GIDC fire station, mutual aid and District authorities
6. Natural Calamity (Flood, Earthquake, lightning etc.)

The project area is sufficiently away from major river - Narmada river. Storm water drainage network is in place and also the floods or abnormally high precipitation may obstruct block the internal roads only for a short period owing to the good drainage.

Dahej GIDC estate falls in the Seismic Zone III. Owing to proximity to sea, cyclonic storms can be expected. There are pressure depressions in the Arabian sea in May and in the post monsoon months causing heavy rains and gusty winds, Thunderstorms during monsoon. However, since the location is near to Gulf of Khambhat, there are no instances of Tsunami in the recorded past.

7.8.1 Sensitive locations around the project

The project site is surrounded by industrial plots on both adjacent sides upto 1 km in the NE, SE and SW quarters whereas the NW quarter is barren land before salt pans.

Table 7-2 Sensitive locations around the project

Sr. No.	Name of the village	Approx. Aerial Dist., From MFB Stack-3 (m)	Direction w.r.t. MFB stack	Type of Area	Upwind or downwind w.r.t predominant wind direction (SW-NE)
1	Western Railway line (Samni-dahej section)	0.99	127° SE	Railway line	Crosswind
2	Dahej (Residential area)	1.1	228.31° SW	Residential	Upwind
3	Madhuram Salt pans	1.24	283.36° NWW	Salt pan	Crosswind
4	Bharuch-Dahej Road	0.91	200.96° SSW	State highway	Crosswind
5	Dahej GIDC estate area	0.88	56° NE	Industrial	Downwind

Google Imagery of site and surrounding features upto 2 km radial distance from site

7.9 EXISTING RISK REDUCTION MEASURES

Proponent is committed to provide inbuilt safety measures with modern & adequate facilities to all new plant sections as already provided to existing plant to reduce the risks involved and control hazards effectively.
The Safety department regularly carries out HAZOP studies, third-party safety audits, internal safety reviews to enhance the level of safety.

7.9.1 Inbuilt Safety at design, construction & commissioning stages

Plant Layout – design, engineering and construction

Existing plant is built as per engineering codes & standards such as ASME, applicable Indian standards (IS) and in compliance with the requirements of Factories Act, 1948. Proponent is committed to build the new plant sections with full compliance w.r.t safety of plant and personnel.

- All equipment and vessels are designed for their desired operating parameters with proper selection of Material of construction, sealing arrangements, properly designed piping and pipe fittings.
- PSVs and TSVs on reactors, gas detectors at required locations.
- Piping layout, electrical layout, utility layout etc. prepared as per standard guidelines to ensure instrinsic safety and ergonomics.
- Dyking, curbing, drains, containments and such other aspects of plant layout incorporated in the expansion project also.
- Civil foundations and structural work to take into account protective measures for earthquakes, cyclones, landslides, flooding etc.
- A well-planned and well-maintained electrical grounding system with sufficient earthing pits provided covering all areas handling flammable chemicals including storages, production areas, loading, unloading areas, warehouses etc.
- Lightning arrester installed at critical locations
- Jumpers provided on flanges to prevent static charge wherever required

Area Segregation**:** -

- There is area segregation for segregated Flame proof and Non Flame proof area as per Zone classification. Same shall be applied for new manufacturing and storage areas also. Flame proof fittings/Equipment will be provided in designated flame proof areas.
- Storage tanks and areas designed and constructed in compliance to the various applicable rules under Manufacture, storage & Import of Hazardous Chemicals Rules, Factories act and Gujarat Factories Rules.
- The bulk chemicals storage area kept away from the main production areas.
- Flame arrestors, water sprinklers, breather valves provided to Storage tanks as per requirement and applicable rules.

Safety at Storage areas

- → Located and marked in the designated area for hazardous material storage.
- → The bulk chemicals storage area to be kept away from the main production areas.
- → tankfarms are constructed with full compliance with applicable rules and regulations
- → Explosive material storage tanks are kept underground & in CCOE Licensed premises,
- → Earthing and Bonding,
- → SOP for tanker unloading,
- → Flame arrester provided on vent
- → DCP Fire Extinguishers shall be available in storage area.
- → Concrete Dyke wall provided to contain spillage / leakages, acid proof tiles provided for each material tanks separately.
- → Storage tank area is away from the process plant and Separation Distance has been maintained.
- → Dyke wall provided to all above ground storage tanks, collection pit with valve provided.
- → Fencing and caution notes and hazard identification boards displayed
- → Only authorized person are permitted in storage tank farm area.

Control Measures Provided: - Fire hydrant water network, Portable Fire Extinguishers, Self Contained Breathing Apparatus, SCBA, Medical facilities, Spill control procedures, Dyke wall for containment.

New storages shall be provided with same preventive and control measures.

Tanks and vessels handling strong acids / alkalis

Preventive Measures provided (to be implemented for new tanks also)

- No ingress of water into any container or line i.e. tank, tanker, pipeline, valve, instrument gauge nozzles, reactor jackets, cooling coils, day vessels, etc.
- Open vents are kept covered from all sides for protection from rain or water sprays.
- Tank are fabricated out of suitable corrosion resistant material.
- Tank capacity are 1.2 to 1.5 times the storage capacity.
- Tanks are placed in dyke or bund designed to contain 110% of the largest tank within the diked area. Acidproof lining are given in dyke.
- Safe access into and out of the diked area must be provided as well as a sufficient number of escape routes.
- The diked area are also provided for the draining and collection of water. The area should be sloped to a centrally located sump where any water or spills can be treated and disposed.
- Tank exterior are painted with white epoxy for protection against atmospheric corrosion and for reflection of solar heat. It is given clear and visible label for identification
- The tanks are provided with level gauge and protected from overflow by level alarm.
- The tank farm is be provided with roof to protect from rain water and located in well ventilated area.
- Storage tanks are protected from water ingress and inspected on periodic basis for rupture and damages
- Inside of tank are buffed to 180 grit to reduce risk of corrosion.
- Tanks are filled using a J pipe to prevent splashing inside the tank.

Chlorine Storage Area:

- Chlorine tonners are stored separately and isolated area in compliance with requirement of Gas Cylinder Rules, 2016.
- Chlorine kit, FRP hood, SBA set, etc. provided
- Each tonner is examined, while receiving.
- Personnel Protective Equipment are issued to workers & operatives.
- Displayment of notice for filled and empty Tonners.
- Water shower with eye-washer provided.
- Chlorine is supplied through header and connector.

For other gas cylinders, separate area has been assigned and in accordance with applicable rules.

Instrumentation and Control System and Emergency Shutdown System

- All plant sections shall be automated to be best possible extent and controlled through PLC/DCS
- Necessary instrumentation shall be provided on vessels and tanks for indication and control.
- Indicators, high and low alarms, NRVs, controllers are provided for pressure, temperature, level wherever required.
- The operators are provided with definite instructions in the form of Do's and Don'ts and Standard Operating procedures (SOPs) for the action to be taken on equipment or process malfunction.
- Interlocks shall also be provided if found necessary from HAZOP or other studies

7.9.2 Operational Safety

Systems and procedures

→ Safe operating procedures are developed for handling of hazardous chemicals and for critical process operations such as loading and unloading tankers, drum charging, drum movement, vessel opening or drum opening, work permit systems. Safety measures to be taken by Transport agency including Emergency action and TREM card are also developed. Tanker drivers are trained in DPMC.

→ Preventive maintenance schedule for all critical equipment and vessels planned and carried out as per checklist. Do's and don'ts for maintenance of critical equipment and machinery prepared and instructed to operators.

→ Work Permit system implemented for hot work in Plant / Storage area, Vessel Entry Permit, Working at Height, Opening of the Process lines.

→ All the equipment and pipelines marked for identification

→ All the safety devices and instruments like safety valves, tested, inspected and recalibrated as per safety norms.
→ Fire hydrant system, Fire extinguishers, fire alarms, detectors examined periodically and preventive maintenance to be undertaken. Fire system audit is carried out once in a year.
→ Hydraulic testing of pressure vessels and tanks done through Government approved Competent Person. (As per rule).
→ Match boxes, Cigarettes, Mobile, any petroleum product prohibited. Visitors required depositing such items at security gate.
→ The organization has developed an on-site emergency plan to handle emergencies and accidents and upgrades it periodically.
→ Head count of all employees inside the Plant premises maintained by the Duty Security Head in a register on the Gate. Similarly, head count of all contract workers maintained.
→ Accident records maintained and top management at headquarters appraised
→ Periodical medical checkup of employees done & health records kept

Employee awareness and training

- Appropriate PPE provided to workers w.r.t type of operation and material handled.
- Training programs are conducted for employees for SOPs and safety as per yearly plan.
- All employees covered under Group Insurance Policy along with personal accident cover
- To check preparedness of workers for emergency control, mock drills on regular basis and disaster drills as per factory inspectorate guidelines to be conducted.
- Fire fighting team with adequate firefighters in each team and having proper training
- Trained first aid team

Fire Fighting Arrangements :
(Source : Onsite plan of Bharat Rasayan Ltd. (Unit II) Dahej – May 2019, Revision 1*)*

Fire Water Network:
The fire hydrant system covers plants buildings, finished product tanks, utility room and storage tank area under occupation. Fire hydrant system shall be augmented to cover new plant section. Necessary network components shall be provided.

Fire water:	No. of tanks: 01 Total Quantity -2000 KL								
Other source & capacity	No. of hydrant points	No. of fire pumps, type & capacity	No. of hose reels & total length	No. of fire tenders and capacity	No. of Sprinklers / Monitors				Alternate power arrangement
					Fixed		portable		
					Lifting height	Pressure	Lifting height	Pressure	
1	2	3	4	5	6	7	8	9	10
---	Total Hydrant Points - 34 Nos. Total Risers Plant-A = 08 Plant B = 10 Plant C = 08 Pilot Plant = 03 Plant D=11	Total 03 Pump Jockey Pump -01 & Capacity - 11 m3/hr Main Electrical Pump- 01 Capacity -273 m3/hr Diesel Pump- 01 Capacity-273 m3/hr	Plant-A=08 Plant-B=08 Plant-C=08 Plant-D=11 Total length= 40 ft x 22	---	Plant-C- 01 No. DMA storage tank farm area- 01 Nos. IB storage tank farm 2 01 Nos. Water Monitor- 6 Nos. Foam monitor- 5 Nos. Portable monitor 1 Nos.	07 kg/m²	---	---	Electricity by Diesel Generator 2 nos. 750 KVA each and one 1500KVA. And Diesel operated hydrant pump

Fire Extinguishers:

Fire Extinguisher Details			
Sr. No.	Type of Extinguisher	Qty	No. of Extinguisher
1	Co2	04.5 Kg	78
2	Co2	22.5 Kg	6
3	DCP	05.0 KG	99
4	DCP	50.0 KG	25
5	Mechanical Foam	09.0 Ltr	88
6	Mechanical Foam	50.0 Ltr	21
7.	AFFF	2000 liter	--
8	AR-AFFF	1000 liter	---
9.	Fire Blankets	6 x 6 mtre	06
		2x2 mtre	02
10	Foam Trolley	200 Lit	07

After proposed expansion, new areas where fire hazards are present shall be provided with fire extinguishers of suitable type and size at all required locations and floors.

List of Personal Protective Equipment

No.	Description	Quantity
1	SCBA Set	8
2	Dust mask, Organic mask, Cartridge respirator.	As per Requirement
3	Hand Gloves Rubber Type, Safety Shoes, Safety Gogles, Gum Boots, Helmet, Safety Belts.	As per Requirement

No. of water sprinklers or monitors (Connected to FWHS and also to Overhead tank)

1. On DMA storage tanks
2. On Acrylonitrile tank
3. On Isobutylene storage tanks (proposed new)
4. On NH3 storage tanks (proposed new) - 2 sets

Figure 7-1 Photographs of existing fire-fighting arrangements

Emergency Communication system :

Intercoms : All the plants/departments are provided with internal phones and external phones are provided at the security gate and the administration building.
All plant offices, electrical substations (MCCs), Maintenance Dept, Instrumentation Dept., Civil and all emergency service departments (like Electrical Dept., Utility Dept.) are connected with internal telephone network which act as an easy and immediate means of communication.

Public Address system : Each and every section, area & department of the plant are connected by Public Adress system which is operated by security main gate.

Emergency siren
There is one electrically operated as well as one manually operable siren near security gate
Declaring emergency using siren :-
- Wailing to declare emergency (at the interval of 10 seconds on and 5 seconds off for 2 minute)
Declaring all clear using siren :-
- Continuous (two minute)
Testing of siren : Once in a week every monday at 11.00 am.
All clear siren is also installed at utilities building and warehouse

Manual call points : Suitable manual call points for fire alarm system are also installed.
Additional manual call points for fire alarm system shall be installed at new areas.

Runners : Plant helpers, operator, contract helpers etc. while working in and around plants can easily notice any abnormal event that might occur. He shall immediately communicate about the same to the security officer at security gate. Security officer will blow siren.

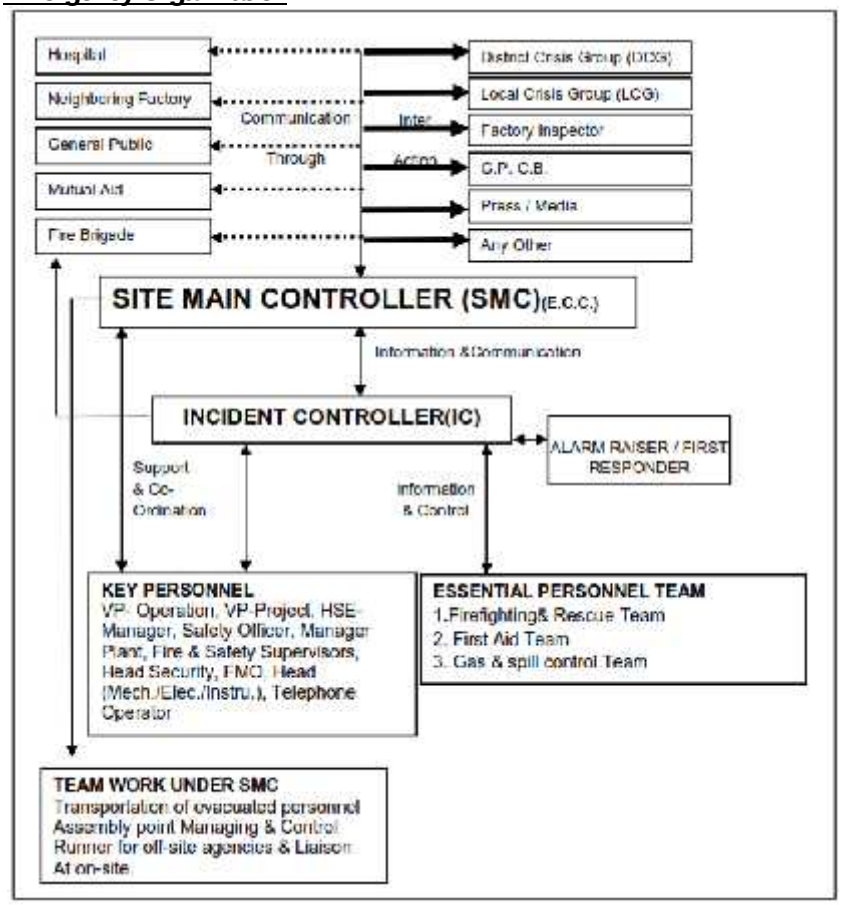
External lines and messages : Emergency communication with local bodies and other organizations are made by phones or by sending messengers. All senior managers have been provided with external telephone connection in their office as well as at their residence.

Detectors & alarms
Detectors shall be placed for hazardous gas detection at their respective storage and handling areas.
EXPLOSIVE METER: It is a portable combustible gas detector which measures the conc. of inflammable gases and vapours contained in atmosphere.
HALOGEN METER; Automatic halogen leak detector to detect leak of halogen gases like chlorine, bromine fluorine etc.
MULTIGAS DETECTOR: It is used to detect various toxic gases present in the atmosphere like chlorine, bromine etc.

Smoke detectors are installed at warehouses, plant buildings and other places wherever required.

Personnel supervision
The operators and supervisor are continuously taking rounds of the plant and monitoring the process parameters through local monitoring instruments provided in the field.
Plant security personnel are present on all gates of premises and strategic location for the security of the plant. Any person or employee or contractor personnel are not allowed without proper purpose / gate pass.

Emergency Organization



Emergency Control Centre (ECC)
Location of the Center : Main control room

ECC is equipped with following items :-

Sr. No.	Item Kept in the Centre	Nos. of Quantity
1	2	3
1	Internal & External Telephone Numbers	36 1
2	Computers with internet and email facility	57
3	Printers / Scanners	20
4	Mobile phone at main gate	1
5	**Personal protective/safety equipment**	
	• Rain weather gear	10
	• Safety Helmet & Hand gloves	400
	• Online Respirators / Portable Respirators/ Air Bubble Hood	07
	• Safety goggles	250
	• Self contained Breadhing Apparatus Set & Filled SCBA Set Cylinder	6
	• Safety Harness / Safety belt	10
	• Ear Plug / Ear Muff	40
6	Gas detection instruments & TVOC metor	01
7	First Aid kit	10
8	Site layout	01
9	Directory of Emergency Coordinator Team	01
10	Directory of Employees.	01
11	Inventory of emergency Material resources.	1 each
12	On site Emergency Response Plan	01
13	Building plans	14
14	Stationary Materials	Available
15	PA System Manual	01
16	Foam Trolly	04
17	Spil kit	04

Safe Assembly Points :-

S.N	Location of Assembly point	Accomodation capacity
1	Near Main Security Gate	@250
2	Near MEE	@250
3	Near PCC Room	@250

First Aid Boxes

First aid boxes have been provided at Security gate, Engg. Dept. plantwise office, Boiler house, ETP and QC lab which are regularly inspected and maintained by the OHC Officers.
First-aid boxes shall be provided at new plant sections also.
Selected employees from each department are trained for first-aid course to be available in all shifts and additional employees of new plant sections shall also be given training. All firstaiders are given refresher training once in a year.
List of trained first aiders is kept in ECC, OHC and onsite emergency plan.

External aid arrangements

Company is member of Dahej Industries Association and therefore emergency help is available from nearby member industries listed below.

Name of Industry / Agency	Approx. distance from site
GCPTCL Fire station, Dahej	1 km
Reliance Industries Ltd. (IPCL) Fire Station, Dahej	5 km
Birla Copper (Hindalco) Fire Station, Dahej	7 lkm
GACL Fire dept. Dahej	10 km
Bharuch Fire Station	51 km

External hospitals and medical officers engaged for medical checkup and emergency treatment

Unit has contract for medical treatment with Dahej Health & Welfare Society Hospital, Dahej and Amax Hospital, Jolva located in GIDC estate. Also Tie-up with Global Bharuch Hospital, Baroda Heart & Multi Speciality Hospital and Healing Touch Multi Speciality Hospital in bharuch.

Unit has own ambulance for emergency transport manned with driver at all times at site for Emergency transport. Ambulance facilities are available from 108 as well as from nearby LSI units.

Mutual aid is also available from nearby industries viz. GCPTCL, Reliance Industries Ltd., Birla Copper, GACL.

Trained Emergency Response Personnel : available in all shifts + general shift in each plant
Trained for :- Fire Fighting / Rescue / SCBA/ First Aid/ Toxic spill control – external as well as internal. Refresher training is a continuous process. Training shall be given to selected workers for using the chlorine emergency kit, SCBA and scrubber hood. Adequate fire fighting personnel shall be made available at new plant sections also.

Trained First-aiders : It is generally organized that any one first aider is each plant available in any shift. Refresher training is a continuous process. Adequate First-aiders shall be made available at new plant sections also.

Training and Rehearsal for Emergency Management
The company is organizing mockdrills in quarterly basis to keep the system in readiness. Mockdrills after proposed expansion shall include new hazardous chemical handling and response procedures.

Further suggestions from EIA consultant

- Emergency power for all critical drives / instruments
- Intelligent / Fuse less MCC for entire site
- Civil foundations and structural work shall take into account protective measures for earthquakes, cyclones, landslides, flooding etc.
- Seamless pipelines to be used wherever necessary.

Occupational Health Centre
An Occupational Health Centre (OHC) in compliance with statutory requirement is developed by the factory management adjacent to Main gate, easily approachable from all directions and having direct access to GIDC road.
Male Nurse is available in each shift. It includes consulting room with necessary accessories for Factory Medical Officer, nursing station, two bedded observation cum treatment room cum record room with oxygenation and other resuscitation facilities, medicines & antidotes, dressing & dispensing cum record room, toilet block, computer – printer, O2 -Portable analyzer system, pulse – oxymeter, ophthalmic charts, eye washer, First–Aid boxes– stretchers. OHC has intercom with zero dial facility. The contact number of all nearby hospitals and medical facilities shall be kept and put up on a board in the center. There is adequate space available for testing
Antidotes for major chemicals handled by the unit are identified and list is attached as Annexure-20. They are provided at the centre.

Visiting CIH doctor is appointed as Factory Medical Officer (FMO) who visits the unit twice in a week – to attend routine work related / non related complaints. FMO is responsible for carrying out pre as well as periodical medical examination. The doctor is also accessible for speedy contact and consultation.

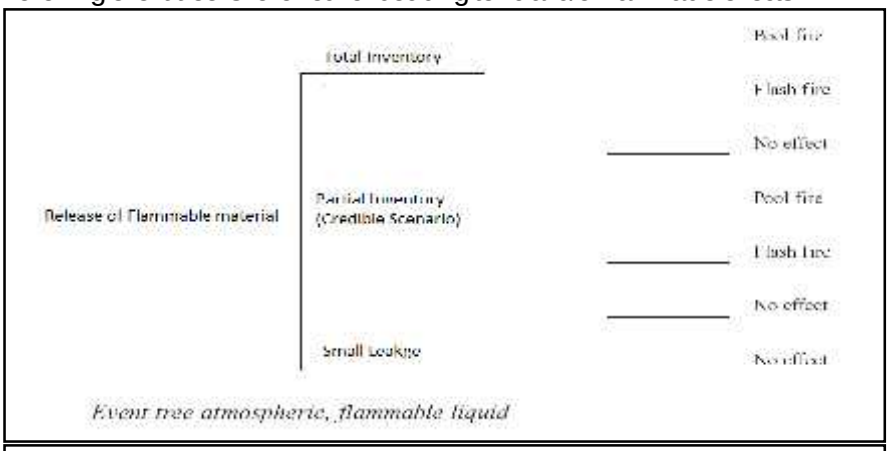
7.10 VISUALIZATION OF ACCIDENT SCENARIOS

- One scenario considered for all is 'Catastrophic Failure', which is the worst case (WC) and frequency of which is very rare in the lifetime of the plant.
- Major hazards posed by hazardous chemical storages can be assessed using MCA (Maximum Credible Accident) analysis. Hence most credible accident scenarios (MCA) are also considered primarily leaks from tanks, vessels or pipelines, drum damage in drum storage area.
  Leak in the vessel or leak from the flange joints of these connections is possible. The leak through flange failure is considered from 50% of flange perimeter and accordingly equivalent area is calculated. This area is approximated to hole of 10mm or 10% of pipe diameter. The small bore pipes less than 2" is considered full bore leak.

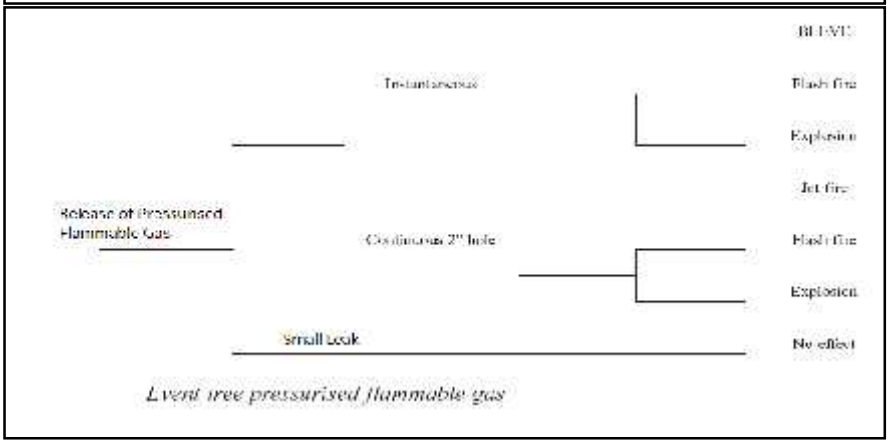
For our analysis we consider leak from pipeline which are at pump discharge, hence it shall be pressurized and feeding to reactor or storage.

7.10.1 Selection of Initiating Events and Scenarios

Following event tree is followed for deciding toxic and/or flammable effects:



Event tree atmospheric, flammable liquid



Event tree pressurised flammable gas

Based on the inventory of hazardous chemicals and their hazardous properties, following accident scenarios have been visualized for the given project.

Table 7-3 Worst Case (WCS) and Most Credible Accident (MCS) Scenarios selected for the study

Sr. No.	Hazardous Chemical Name	Storage Parameters		Equipment Considered	Scenario Selected	Type Of Scenario	Flammable/ Toxic
		Temp (°C)	Pressure (kg/cm2)				
1	Ammonia gas in cylinder	Amb.	10	Cylinder	MCS	Leak in pipeline after pump discharge during transfer	Toxic
2	Ammonia gas in tank	Amb.	10	tank	MCS	Leak in pipeline after pump discharge during transfer	Toxic
3	Acetone	Amb	Atm	drum	MCS	drum failure	Flammable
4	Acetonitrile	Amb	Atm	drum	MCS	drum failure	Flammable
5	Acrylonitrile	Amb	Atm	tank	MCS	Leak in pipeline after pump discharge during transfer	Toxic & Flammable
6	Bromine	Amb	Atm	tank	MCS	Leak in pipeline after pump discharge during transfer	Toxic
7	Butanol	Amb	Atm	drum	MCS	drum failure	Flammable
8	Chlorine	Amb	5 kg/cm2	Tonner	MCS	Tonner damage	Toxic
9	Chloro Acetyl Chloride	Amb	Atm	drum	MCS	drum failure	Toxic
10	Dimethyl Amine (99%)	Amb	3.5 kg/cm2	tank	WCS & MCS	Catastrophic failure & Leak from aperture	Toxic & Flammable
11	Isobutylene	Amb	1.8 kg/cm2	tank	WCS & MCS	Catastrophic failure & Leak from aperture	Flammable
12	Hexane	Amb	Atm	tank	MCS	Leak in pipeline after pump discharge during transfer	Flammable
13	Hydrogen	Amb	150	Cylinder	MCS	Leak through 10 mm hole in tubing	Flammable
14	HCl 30%	Amb	Atm	tank	MCS	Leak in pipeline after pump discharge during transfer	Toxic
15	HCl gas	Amb	40 bar	Cylinder	MCS	Leak through 10 mm hole in tubing	Toxic
16	Hydrobromic acid	Amb	Atm	drum	MCS	drum failure	Toxic
17	Methanol	Amb	Atm	tank	MCS	Leak in pipeline after pump discharge during transfer	Flammable
18	Phenyl Chloroformate	Amb	Atm	drum	MCS	drum failure	Toxic
19	Propylene Oxide	10	3.5 kg/cm2	tank	WCS	Catastrophic failure	Flammable
20	Tert. Butyl amine	Amb	Atm	drum	MCS	drum failure	Toxic & Flammable

WCS : Worst Case Scenario MCS : Most Credible Scenario

7.11 CONSEQUENCE ANALYSIS

Hazardous substance on release can cause damage on a large scale in the environment. The extent of damage is dependent upon the nature of the release and the physical state of the material. It is necessary to visualize the consequences and the damages caused by such releases. The quantification of the damage can be done by means of various models, which can further be related in terms of injuries and damage to exposed population and buildings.

Software used for consequence analysis for proposed project: ALOHA (AREAL LOCATIONS OF HAZARDOUS ATMOSPHERES)

Is part of the CAMEO suite developed by US Environmental Protection Agency (EPA), ALOHA® is an atmospheric dispersion model used for evaluating releases of hazardous chemical vapors, including toxic gas clouds, fires, and explosions. Using input about the release ALOHA generates a threat zone estimate. A threat zone is the area where a hazard (such as toxicity, flammability, thermal radiation, or damaging overpressure) is predicted to exceed a user-specified level of concern. Threat zones can also be plotted on maps with MARPLOT to display the location of facilities storing hazardous materials and vulnerable locations (such as hospitals and schools). Specific information about these locations can be extracted from CAMEO information modules to help make decisions about the degree of hazard posed.

In order to assess the damage, the damage criteria have to be first defined.
There are three principle types of exposures to hazardous effects

Heat radiation from a jet, pool fire, a flash fire or a BLEVE
Explosion,
Toxic effects, from toxic materials or toxic combustion products

A basis for the weather conditions (Temperature, wind speed etc.) is chosen for input in these models.

7.11.1 Frequencies Estimation:

No.	Item	Mode Of Failure	Failure Frequency
1	Atmospheric Storage Tanks	Catastrophic Failure	10E-9 /yr
		Significant Leak	10E-5 /yr
2	Process Pipelines		
	<=50mm Dia	Full Bore rupture	8.8 x 10E-7 /yr
		Significant Leak	8.8 x 10E-6 /yr
	>50mm<=150mm Dia	Full Bore rupture	2.6 x 10E-7 /yr
		Significant Leak	5.3 x 10E-6 /yr
	<150mm Dia	Full Bore rupture	8.8 x 10E-7 /yr
		Significant Leak	2.6 x 10E-6 /yr
3	Hoses	Rupture	3.5 x 10E-2 /yr
4	Pressure Vessel	Catastrophic Failure	3 x 10E-6 /yr
		Significant Leak(6" nozzle)	7 x 10E-6 /yr
5	Liquid Line	Pipeline Leak	3 x 10E-7 /yr
		Fittings Leak	5 x 10E-6 /yr
6	vapor line	Leak	3 x 10E-6 /yr
7	6" Pipe	Leak (1 kg/s)	6x 10E-6 /yr
8	3" Pipe	Leak (1 kg/s)	6 x 10E-5 /yr
9	Flange	Leak (1 kg/s)	3 x 10E-4 /yr
10	Pump Seal	Leak (1 kg/s)	5 x 10E-3 /yr

For warehouse where the drums of chemicals are stored and handled the frequencies are as follows:

No.	Item	Mode Of Failure	Failure Frequency
1	storage of substances in warehouses with protection levels 1 and 2	Liquid Spill	1 x 10E-5 Per handling
		Fire	8.8 x 10E-4 / yr
2	storage of substances in warehouses with protection level 3	Liquid Spill	1 x 10E-5 Per handling
		Fire	1.8 x 10E-4 / yr

Failure History data

No.	Item	International Data	Indian Data
1	Process Controller	2.4 x 10-5 hr-1	3.0 x 10-5 hr-1
2	Process Controller Valve	2 x 10-6 hr-1	2.4 x 10-5 hr-1
3	Alarm	2.3 x 10-5 hr-1	4.6 x 10-5 hr-1
4	Leakage at biggest storage tank	5 x 10-5 yr-1	3.0 x 10-5 yr-1
5	Leakage pipe line	1 x 10-7 m-1yr-1	3.0 x 10-8 m-1yr-1
6	Human failure	1 x 10-4 (demand)-1	1.8 x 10-3 (demand)-1

Assumed failure rate for the study

No.	Item	Rupture (yr-1)	Leakage (yr-1)
1	Pipe lines <3" 3"-15" >15	 10-6 10-7 --	 10-5 10-6 10-8
2	Vessel - pressurized - Atmospheric	 5 x 10-6 1 x 10-5	 5 x 10-5 1 x 10-4

Damage Due To Incident Radiation Intensity

Incident Radiation Intensity (kW/m²)	Type of Damage
62.0	Spontaneous ignition of wood
37.5	Sufficient to cause damage to process equipment
25	Minimum energy required for ignite wood at infinitely long exposure (non piloted)
12.5	Minimum energy required of piloted ignition of wood, melting plastic tubing etc.
4.0	Sufficient to cause pain to personnel is unable to reach cover within 20 sec.; however blistering of skin (1st degree burns) is likely
1.6	Will cause no discomfort on long exposure

Heat Radiation & Escape Time

Radiation Intensity BTU/hr/ft²	Time to Pain Threshold (Seconds)
440 (1.39 kW/m²)	60
550 (1.6 kW/m²)	40
740 (2.33 kW/m²)	30
920 (2.9 kW/m²)	16
1500 (4.7 kW/m²)	9
2200 (6.93 kW/m²)	6
3000 (9.5 kW/m²)	5
3700 (11.66 kW/m²)	4
6300 (19.9 kW/m²)	2

Tolerable Over Pressure Limits For Various Objects

Incident Over Pressure (Bar)	Incident Over Pressure (psi)	Object
0.02	0.29	Schools
0.04	0.59	Domestic Housing
0.05	0.74	Public Roads
0.07	1.03	Ordinary Plant Buildings
0.10	1.47	Buildings with shatter-resistant windows fixed roof tanks containing highly flammable or toxic materials
0.20	2.94	Floating roof tanks, other fixed roof tanks, cooling towers, utility areas site roads
0.40	5.88	Other hazardous plants
0.70	10.29	Non-hazardous (if occupied) plants. Control room designed for blast resistance.

7.11.2 Assumptions Common for all Scenarios

Maximum Temperature	Deg.C	45
Minimum Temperature	Deg.C	11
Maximum Wind speed	m/s	8
Minimum Wind speed	m/s	3
Wind Direction	From	South West / North east
Humidity	%	70 / 50
Ground Roughness		Urban or Forest
Cloud Cover	%	50

- Atmospheric stability class D and E are considered for analysis based on the temperature & wind velocity of the area. The software prompts most suitable stability class based on temperature & wind velocity.
- Stability class D & wind velocity 8 m/s represents most turbulent atmosphere at site which is ideal to analyse effects within or nearby plant area. Stability class E and wind velocity 3 m/s represents most stable atmosphere at the site which is ideal to analyse effects at far distances.
- For any particular case if other stability class is chosen, it is included in its detail analysis.
- At respective class atmospheric temperatures, if flash point is higher and chemical may not ignite. But to assess the radiation effect at such situations, the radiation effect is calculated assuming burning is started due to other ignition source.
- For chemicals having flash point more than 45 degC, the effect is analsyed only for class D.
- For all toxic material release LC50 are taken as the toxic end points. If LC50 is not available then LD50 values are considered
- For thermal radiation the distances for radiation level 37.5 kw/m^2, 4 kw/m^2 and 1.6 kw/m^2 are calculated.
- For vapor cloud explosion the distance for overpressure of 0.5 psi is calculated.
- For gas services the flow through leak is calculated in ALOHA by modelling leak through pipe with closed off (i.e. isolated portion). But this will give the rate which will be present only after isolation. The decreasing pressure inside pipe will affect the discharge rate. The rate of discharge before isolation will be at constant pressure and hence will be more than the rate calculated by ALOHA.
- Specific assumptions are mentioned in the detailed description of each scenario in following sections. The ALOHA text summary output is annexed as Annexure - 12.

7.11.3 Summarized Table for effects of Consequences

Table 7-4 Flammable End points of Consequence Analysis

Sr. No.	Hazardous Chemical Name	Equipment Considered	Scenario Selected	Stability Class	Flash Fire Envelope Diameter (60% of LEL), m	Explosion Overpressure Distance for 0.5psi, m	pool/ Jet Fire	Burn Duration minutes	Heat Irradiation Maximum distances, m		
									37.5 kw/m2	4 kw/m2	1.6 kw/m2
1	Acetone	drum	drum failure	8D	<10	--	pool fire	5	<10	11	14
				3E	<10	--		6	<10	11	15
2	Acetonitrile	drum	drum failure	8D	<10	--	pool fire	7	<10	<10	11
				3E	<10	--		8	<10	<10	12
3	Acrylonitrile	tank	Leak in pipeline after pump discharge during transfer	8D	<10	--	pool fire	11	<10	<10	14
				3E	<10	--		12	<10	11	15
4	Butanol	drum	drum failure	8D	<10	--	pool fire	6	<10	<10	13
				3E	<10	--		7	<10	11	15
5	Dimethyl Amine (99%)	tank	Leak from aperture	8D	13	15	Jet fire	<60	10	12	18
				3E	11	18	Jet fire	<60	10	10	10
			Catastrophic failure	8D	--	--	Fireball dia 140 m	10 seconds	119	409	636
				3E	--	--	Fireball dia 140 m	10 seconds	137	459	717
6	Isobutylene	tank	Leak from aperture	8D	18	15	Jet fire	<60	10	15	23
				3E	11	17	Jet fire	<60	10	11	17
			Catastrophic failure	8D	--	--	Fireball dia 120 m	9 seconds	121	397	616
				3E	--	--	Fireball dia 120 m	9 seconds	121	397	616
7	Hexane	tank	Leak in pipeline after pump discharge during transfer	8D	<10	--	pool fire	5	<10	19	25
				3E	<10	--		7	<10	19	27
8	Hydrogen	Cylinder	Leak through 10 mm hole in tubing	8D	--	--	Jet fire		<10	<10	10
				3E	--	--	Jet fire		<10	<10	11
9	Methanol	tank	Leak in pipeline after pump discharge during transfer	8D	<10	--	pool fire	40	<10	<10	<10
				3E	<10	--		43	<10	19	27
10	Propylene Oxide	tank	Catastrophic failure	8D	13	25	pool fire	52	10	23	30
				3E	28	52		52	10	25	36
				8D	--	--	Fireball dia 125 m	9 seconds	95	341	532
				3E	--	--	Fireball dia 125 m	9 seconds	111	382	598
11	Tert. Butyl amine	drum	drum failure	8D	<10	--	pool fire	2	<10	16	21
				3E	<10	--		3	<10	16	23

Table 7-5 Toxic End points of Consequence Analysis

Sr. No.	Hazardous Chemical Name	Equipment Considered	Type Of Scenario	End Point	Stability Class	Endpoint Concentration	Maximum Distance, m
1	Ammonia gas in cylinder	Cylinder	Leak through 10 mm hole in tubing	LC50, rat, 4 hr	8D	1.4 mg/L	22
					3E		27
2	Ammonia gas in tank	tank	Leak in pipeline after pump discharge during transfer	LC50, rat, 4 hr	8D	1.4 mg/L	47
					3E		125
3	Acrylonitrile	tank	Leak in pipeline after pump discharge during transfer	LC50, rat, 4 hr	8D	2.09 mg/L	<10
					3E		<10
4	Bromine	tank	Leak in pipeline after pump discharge during transfer	LC50, rat, 0.5 hr	8D	435 ppm	33
					3E		22
5	Chlorine	Tonner	Leak through 10 mm hole in tubing	LC50, rat, 0.5 hr	8D	500 ppm	44
					3E		40
6	Chloro Acetyl Chloride	drum	drum failure	LC50, rat, 1 hr	8D	660 ppm	<10
					3E		<10
7	Dimethyl Amine (99%)	tank	Catastrophic failure & Leak from aperture	LC50, rat, 6 hr	8D	4540 ppm	33
					3E		16
8	HCl 30%	tank	Leak in pipeline after pump discharge during transfer	LC50, rat, 4 hr	8D	1562 ppm	<10
					3E		<10
9	HCl gas	Cylinder	Leak through 10 mm hole in tubing	LC50, rat, 4 hr	8D	1562 ppm	53
					3E		61
10	Hydrobromic acid	drum	drum failure	LC50, rat, 1 hr	8D	2858 ppm	<10
					3E		11
11	Phenyl Chloroformate	drum	drum failure	LC50, rat, 4 hr	8D	280 mg/m3	156
					3E		437
12	Tert. Butyl amine	drum	drum failure	LC50, rat, 4 hr	8D	3.8 mg/L	18
					3E		13

Detailed output of aloha is attached as Annexure – 12.

7.11.4 Inference of Consequence analysis

Pool fires of flammable material leaked from discharge pipeline

→ The maximum distance for thermal radiation of 4.0 KW/m2 radiation which is sufficient to cause pain to personnel is obtained as 19 m for methanol pool fire.

→ Firefighting arrangements shall be provided beyond this distance.

Pool fire from Drum failure :

Heat radiations from pool fires shall be limited to plant upto 11 m for 4 kw/m2. The radiation of 1.6 kw/m2 will be experienced up to 25 m around the warehouse.

Jet fires (Hydrogen, DMA and Isobutylene)

The major consequence is jet fire from leak in pressurized tanks and cylinders storing flammable material. The 4 kw/m2 radiation distance which can cause pain and blistering of skin is upto 15 m max. for Isobutylene which shall be around the tankfarm area.

Firefighting arrangements shall be provided beyond this distance.

Fireball effect (DMA, Propylene Oxide, Isobutylene)

- The fire ball diameters shall range from 120 m for Isobutylene to 140 m for DMA. The fireball shall exist for @ 10 sec. This can be interpreted as inside the process area all the equipments will be engulfed by this fire ball.
- Although this fire fireball is of 10s duration, but it can ignite the hydrocarbon released from damaged vessels, equipments in nearby or in the same building/structure, due to explosion (both - physical & vapor cloud).
- The scenarios need to be addressed in Onsite emergency plan.

Non-flammable toxic material storage tank

- For 30% HCl and Acrylonitrile leak scenario, the LC50 distances will remain at less than 10m and remain within plant.
- For bromine and DMA leak, the LC50 distance will remain within 33 m.
- Eye shower and full showers should be placed near the location.

Toxic material Drum Storage :

The most of the raw materials are stored and handled in 200 lits drums. The drum failure during handling is analysed as most credible scenario.

LC50 concentration are less than 10 m and within the warehouse area except for chloroformates which are extremely toxic and their effects shall be experienced to larger distances if not controlled promptly.

Portable gas detectors should be used for emergency response procedures.

Eye shower and full showers should be placed near the location.

Cylinder and Tonner storages (HCl gas cylinders, Ammonia gas cylinder & Chlorine tonners)

- For pressurized gas storages in cylinders and tonners, LC50 values upto 60 m for HCl, upto 44 m for Chlorine and 125 m for Ammonia are obtained which indicate that these scenarios should be included in off-site emergency planning and onsite control actions have to be started speedily to contain the spilled liquid and prevent from spreading.
- Also spilled material should be covered immediately, material required for covering should be kept handy while pumping is on.
- Portable gas detectors should be used for emergency response procedures.
- However, there are no residential villages covered in these distances, the manpower within the GIDC estate might be affected.

7.11.5 Risk to Individuals from a Major Release

Basis of estimation

→ The risk to health to an individual at a specific point in the direction of the plume or heat radiation is dependent on a number of factors, the most important being:

— the direction of the wind when the release takes place; and

— mitigating factors, such as whether the individual might be indoors or out of doors.

- → In the case of the wind direction, the plume width may be represented by the sector of a circle having an included angle of 15°. In such a case, on the basis that wind direction arise, it is possible to approximate that an individual present in a single location for one year may be exposed for only 15/360ths of that year, or 4 x 10-2
- → In reality, it is unlikely that a person would be present at any one location in the open air for 100% of the year. Allowing for periods at work or indoors, a risk reduction factor of 3 is reasonably conservative.(three shift operation is considered)
- → Also the fatality % due to radiation is assumed at 50%.This assumption is based on the response time and the duration of fire in our case.
- → The overall consequence of the mitigation due to wind direction and indoor/outdoor location would be the product of these three factors, namely 1.33 x 10-2.
- → The overall chance of an individual being affected at a specific location by exposure to the toxic gases would be as indicated in following table. From the table it is clear that for catastrophic failure the distance for 50% fatality is more than MCS scenarios.

Flammable effect

No	Hazardous Chemical	Incident/Different Cases	Consequence Effect Overpressure(psig)/ Radiation(kw/m2)	Frequency of Occurance per yr	No of Vessels/Reactors (No of Probable Sources)	Frequency of Occurance per yr	Consequence Mitigation factor	Frequency of Occurance per yr (Representing Individual Risk)	Cummulative Individual Risk (Areawise)
1	Acetone	Drum Damage	Pool fire	1.00E-05	25	2.50E-04	1.33E-02	3.33E-06	3.33E-06
2	Acetonitrile	Drum Damage	Pool fire	1.00E-05	50	5.00E-04	1.33E-02	6.65E-06	9.98E-06
3	Acrylonitrile	Leak in pipeline after pump discharge during transfer	Pool fire	1.00E-06	1	1.00E-06	1.33E-02	1.33E-08	9.99E-06
4	Butanol	Drum Damage	Pool fire	1.00E-05	50	5.00E-04	1.33E-02	6.65E-06	1.66E-05
5	Dimethyl Amine (99%)	Leak from aperture	jetfire	1.00E-05	1	1.00E-05	1.33E-02	1.33E-07	1.68E-05
6	Dimethyl Amine (99%)	Catastrophic failure	fireball	5.00E-06	1	5.00E-06	1.33E-02	6.65E-08	1.68E-05
7	Isobutylene	Leak from aperture	jetfire	1.00E-05	2	0.00002	1.33E-02	2.66E-07	1.71E-05
8	Hexane	Leak in pipeline after pump discharge during transfer	fireball	1.00E-06	1	0.000001	1.33E-02	1.33E-08	1.71E-05
9	Hydrogen	Leak through 10 mm hole in tubing	jetfire	1.00E-05	20	0.0002	1.33E-02	2.66E-06	1.98E-05
10	Methanol	Leak in pipeline after pump discharge during transfer	Pool fire	1.00E-06	1	0.000001	1.33E-02	1.33E-08	1.98E-05
11	Propylene Oxide	Catastrophic failure	fireball	5.00E-06	1	0.000005	1.33E-02	6.65E-08	1.99E-05
12	Tert. Butyl amine	Drum Damage	Pool fire	1.00E-05	50	0.0005	1.33E-02	6.65E-06	2.65E-05

Toxic effect

No	Hazardous Chemical	Incident/Different Cases	Frequency of Occurance per yr	No of Joints/Flanges/ Valves / Containers (No of Probable leaks)	Frequency of Occurance per yr	Consequence Mitigation factor	Frequency of Occurrence per yr (Representing Individual Risk)	Cummulative Individual Risk (Areawise)
1	Ammonia gas in cylinder	Leak through 10 mm hole in tubing	toxic vapor release	1.00E-05	10	1.00E-04	1.33E-02	1.33E-06
2	Ammonia gas in tank	Leak in pipeline after pump discharge during transfer	toxic vapor release	1.00E-05	2	2.00E-05	1.33E-02	2.66E-07
3	Acrylonitrile	Leak in pipeline after pump discharge during transfer	toxic vapor release	1.00E-06	1	1.00E-06	1.33E-02	1.33E-08
4	Bromine	Leak in pipeline after pump discharge during transfer	toxic vapor release	1.00E-06	2	2.00E-06	1.33E-02	2.66E-08
5	Chlorine	Leak through 10mm hole	toxic vapor release	1.00E-05	40	4.00E-04	1.33E-02	5.32E-06
6	Chloro Acetyl Chloride	Drum failure	toxic vapor release	1.00E-05	100	1.00E-03	1.33E-02	1.33E-05
7	Dimethyl Amine (99%)	Leak through 10mm hole	toxic vapor release	1.00E-05	1	1.00E-05	1.33E-02	1.33E-07
8	HCl 30%	Leak in pipeline after pump discharge during transfer	toxic release from pool	1.00E-06	2	2.00E-06	1.33E-02	2.66E-08
9	HCl gas in cylinder	Leak through 10 mm hole in tubing	toxic vapor release	1.00E-05	10	1.00E-04	1.33E-02	1.33E-06
10	Hydrobromic acid	Drum failure	toxic release from pool	1.00E-05	40	4.00E-04	1.33E-02	5.32E-06
11	Phenyl Chloroformate	Drum failure	toxic release from pool	1.00E-05	10	1.00E-04	1.33E-02	1.33E-06
12	Tert. Butyl amine	Drum failure	toxic release from pool	1.00E-05	50	0.0005	1.33E-02	6.65E-06

7.12 RECOMMENDATIONS

Drums and carboys Storage

- In drum storage area in warehouse, toxic and flammable materials shall be stored separately.
- The area shall be provided with small bund wall (100 mm) to contain any spill.
- The warehouse shall be well ventilated.
- The warehouse shall have emergency exits
- Smoke detector and/or automatic actuated DCP extinguishers should be installed to get early warning and control of any fire incident
- The fittings in flammable storage area should be classified fittings.
- Safety shower & eye washer to be placed near warehouse.

The list of chemicals or names of chemicals and actions in case of spill should be displayed in store area. The required neutralizers and spill kit (Soaker- adsorbers / PPEs / Disposal bags) should be kept in storage area.

Flammable Tank Storage Area:

- As the tankfarm is constructed is as per PESO guidelines, it has sufficient fire water network providing hydrants and monitors around Tank, reactor building/ process area.
- Suitable foam and DCP fire extinguishing system should be used for pool fire fighting. This can be semi fixed system with connections to all tanks and dykes and portable foam cans can be used along with fire water monitors around tank farm.
- Fire ring should be surrounding the tankfarm from all sides.
- The fire fighting distance should be from at distance of minimum 15m from tank dyke with fire resistant clothing.
- Fireproofing requirement of structure and equipment supports needs to be analysed and fireproofing to be provided accordingly.
- No pumps to be installed inside the dyke.
- The tanks shall be provided with breather valve with flame arrester and emergency vent.
- All transfer pumps should have double mechanical seals.
- The tanks shall be provided with breather valve with flame arrester and emergency vent.
- Emergency vehicle shall be able to move around Flammable Tanks.
- All pipeline flanges handling flammable liquids should be connected with metallic jumpers to avoid accumulation of static charge.

Bullet Storage and Atmospheric storage tank Area

- The bullet and storage tanks handling highly flammable materials(Isobutylene, DMA, Acrylonitrile, Propylene Oxide) should have remote operated valves on inlet & outlet lines to isolate in case of emergency.(Ref SMPV Rule and for Guideline Ref OISD 144)
- The gas detection will provide early information of the leak and it will provide some time to take corrective action (isolation, stopping of pump etc) to avoid the incident. Consider placing gas detectors at strategic places in storage area.
- In bullet area the hydrocarbon gas detectors shall be on vessel top, pump suction line outlet at bullet and in transfer area. In process area also HC gas detectors to be provided.
- All bullets and storage tank shall be fully covered by FW monitors from both sides.
- All bullets shall be provided with automatic medium velocity fire water spray system. This will keep the bullet or tank cool in case of fire in the plant and prevent failure of the equipment. The BLEVE /fire ball can be prevented by this system.
- The regular inspection of the FW spray system and FW network along the storage area should be done with schedule.
- Ensure safety shower and Eye wash is placed in storage area.
- The storage temperature of bullet storage is very important factor to reduce the consequence of releases. The chilling water system maintaining this temperature is hence a safety system .This system shall be always in line and shall be maintained regularly.

Non Flammable and Toxic Tank:

- Fire water network providing hydrants and monitors should be around Tank.
- No pumps to be installed inside the dyke.
- Safety shower & eye washer to be located opposite the tankfarm area at a distance of more than 6 m to prevent water ingress near acid tanks.
- Breather valve and emergency vent shall be provided.
- Unloading shall be carried out using standard procedures for acids
- Tanks shall be prevented from overflow level alarm and return line.

Chlorine Tonner Storage Area

- Chlorine gas monitors are installed which should be maintained and inspected regularly for effectiveness and set alarm level.
- Chlorine gas is heavier than air so gas monitors should be mounted approximately two feet from the floor for quick and accurate detection.
- FRP hood, chlorine kit and neutralizing agent should be placed in ready-to-use condition
- Only trained personnel to attend leaking tonners
- Regular training and mock drills for using FRP hood and chlorine kit and emergency action for tonner leak should be conducted
- If fire is present or imminent, chlorine containers and equipment should be moved to a safe location, if possible.
- Non-leaking containers or equipment that cannot be moved should be kept cool by the application of water. This should continue until well after the fire has been extinguished and the containers are cooled.

Hydrogen & HCl Cylinder Area

- Gas detectors to be placed near cylinder bank area and reactor area.
- Hydrogen cylinder bank should be placed at distance (min 15m) from reactor area. The bank area should be covered with FW monitor and hydrants.
- Only trained personnel to attend leak

Instrumentation & Control:

- DCS connectivity should be provided to the maximum extent possible to reduce manual errors.
- Indicators, alarms should be installed at plant levels and loading and unloading areas to alert workers around.
- Interlocks for pumps, remote switches for sprinklers should be considered.
- The alarm should be provided on either temperature or pressure based on the nature of process (exothermic or high pressure reaction)

Reactor area

- The mitigation controls to avoid damage due to reactor explosion are of two types, to avoid the runaway to happen and other measure to minimize the damage if any abnormality occurs.
- To avoid disturbances and abnormal scenarios, the safety systems which will detect high temperature and pressure which are provided by licensor, shall be maintained and tested with fixed maintenance schedule
- The cooling water system should be provided emergency supply and auto cut in provision for standby cooling water pump should be provided.
- Alarms and interlock can be provided on cooling water side to detect any failure as this is direct measurement
- To minimize damage once runaway occurs, Safety valve on the reactor should be designed to take care abnormal reaction scenario or as per licensor's recommendation.
- The steel structure and safety interlock cabling within process area should be fireproofed
- Spiral wound gaskets are recommended for hydrocarbon lines. Screwed fittings should not be used except for stainless steel instrumentation.
- Fire water network providing hydrants and monitors should be around reactor building/ process area. Also provision of hydrants on elevated structures and buildings to be ensured.
- Fireproofing requirement of structure and equipment supports needs to be analysed and fireproofing to be provided accordingly.
- The process area should be classified area for selection of electrical equipments and instruments.

- The construction and fabrication should be as per standard codes and practices (ASME /ANSI / IS etc) as the failure frequencies will be valid for such construction. If there is some deviation then the frequencies may increase.

General

- Ensure that all electrical installations and instruments are as per hazardous area classification (ref IS 5571 & 5572).
- Spiral wound gaskets are recommended for hydrocarbon lines. Screwed fittings should not be used except for stainless steel instrumentation.
- The process area should be classified area for selection of electrical equipments and instruments.
- The construction and fabrication should be as per standard codes and practices (ASME /ANSI / IS etc) as the failure frequencies will be valid for such construction. If there is some deviation then the frequencies may increase.
- On long pipelines of solvents, thermal relief valves should be fitted, the relief valve must vent to a safe location, e.g. the storage tank as this is liquid relief.
- The plants shall be handling extremely flammable materials. It is important to detect the leakage of such chemicals at early stages to have effective response. For this the gas detectors to be placed at strategic locations in the plant area and at battery limit is very much important.
- Critical switches and alarms shall always be kept online especially in reactor area.
- Provide training for employees in the procedures established for their operating and maintenance functions. Also a refresher training program at specific intervals is to be prepared to keep operators updated.
- Shut off and isolation valves shall be easily approachable in emergencies
- wind direction pointers shall be well maintained for visibility and operation so that in an emergency the wind direction can be directly seen and downwind population cautioned
- Ignition exclusion Zones of the Plant shall be clearly marked with 'No Sparks Zone'.
- Use of portable electrical instruments such as transistor radio or cellular phone handsets should not be allowed to be carried in the Plant premises.
- Smoking shall be prohibited in designated locations. Work likely to involve flame or sparks, such as, welding or burning, shall be performed only after the area is checked for no presence of flammable material and other safety arrangement as required.
- The fire fighters crew who is responding to emergency involving such chemicals should be aware of toxic effects of stored chemicals and should use the advised PPEs for those chemicals.
- Proper training shall be given to the staff to handle any emergency situation and use of PPE during the work and emergency.
- Self-Contained Breathing apparatus (SCBA) shall be well maintained for emergency handling.
- Personal protective equipments to be provided to all the employees related to the type of work and hazard associated.
- Mutual aid from neighboring industries to be made available whenever need arises.
- To check preparedness of workers for emergency control, mock drills on regular basis and disaster drills as per factory inspectorate guidelines to be conducted.
- All the safety devices and instruments like safety valves, shall be tested, inspected and recalibrated as per safety norms
- Fire extinguishers, fire alarms, detectors shall be serviced and examined periodically and preventive maintenance to be undertaken.
- Hydraulic testing of pressure vessels, and tanks shall be done through Government approved Competent Person. (As per rule).

All Fire fighting arrangements as described above shall be augmented for the new manufacturing sections.

7.13 DISASTER MANAGEMENT PLAN

The proponent M/s. Bharat Rasayan Limited is an established group and as regards the proposed expansion, existing manufacturing sections are operating successfully and safely at the site. The proposed new plants shall be more of a replica of the existing w.r.t production, manufacturing processes, utilities, chemical inventory, process control, safety aspects etc. and with better plant technology.

There shall be inbuilt safety in the plant through DCS and PLC operations and safety interlocks wherever required. Also the technology adopted is the most proven technology already implemented in similar units of the group. The plant

design and layout aspects also comply with the applicable regulations and requirements of industrial ergonomics. Thus, the risks associated with the project are having low probability and severity.

BRL-D management has prepared and implemented an on-site emergency plan in compliance to the requirements of Schedule 8A under rule 68J(12)(1) of Gujarat Factories Rule 1963 (2004) and schedule 11 under Rule 13 (1) of The Manufacture Storage and Import of hazardous chemicals Rules, 1989, amended 2000. The DMP includes emergency preparedness plan, emergency response team, emergency communication, emergency responsibilities, emergency facilities, and emergency actions. The content page of onsite plan is annexed as Annexure -9.
The plan also includes an OFF site emergency plan for the concerned government authority giving details about steps to be taken to inform related Government agencies, Medical Centers, Rescue teams and other local agencies, in an event where the emergency poses danger to surrounding area requiring evacuation.

Unit is member of Dahej Industries Association and has mutual aid arrangements with nearby LSIs of the estate for immediate assistance in fire and toxic release emergencies.

EIA Consultant has reviewed the latest plan (*Rev 01, May 2019*) assessing suitability and adequacy w.r.t proposed expansion. The review points are mentioned herewith.

As per latest plan -	**Review and suggested modifications**
Objectives of DMP	Adequately addressed in Foreward, may be mentioned as a dedicated chapter .
Components of DMP	Included, Updation in Annexures in prescribed formats
Emergency Response • Written procedures for controlling different types of emergencies • Availability of emergency response equipment with location and quantity and incharge	• Training of workforce for procedures and individual roles and responsibilities • Additions of emergency response procedures for new chemicals to be handled for expansion Following points shall be kept in mind while preparing the procedures : • The exposure of workers to be limited as much as possible during the operation • Contaminated areas should be cleaned and, if necessary disinfected • Limited impact on the environment at the extent possible.
Levels of Emergency	Suitable, Onsite plan shall be revised to identify and include emergencies from new plants.
Emergency Communication system	Adequate, new manual call points and sirens to be included Proper instruction boards shall be installed at new plant sections to inform new employees and workers about the assembly points. Training on the same shall be given
Emergency Control Centre (ECC) – Main control room	Updated documents at ECC related to new emergency response team of new plants
Emergency Management Team & Emergency organogram	additional personnel from new plant sections to be added The plan designates all positions and also defines the roles and responsibilities of Site Controller, Incident Controller and other key personnel for emergency control. Personnel from new plant sections shall be added in the list of all positions of emergency management team.

Specific precaution during construction phase and after expansion
There shall be additional manpower employed in the plant during construction phase as well as operational phase of the expansion including contract labour. This additional manpower, particularly construction labour shall be given proper

training on the levels of emergency and their role during emergency. Regular inspection and examination of their awareness about possible incidences and their emergency response shall be undertaken by EHS personnel. Mock drill for construction labour is also suggested.

Additions required :

- Mitigation of Environmental Impact during emergency for -
  - Fire, Explosion
  - Chemical Spillage
  - Mitigation of Environmental Impact during emergency for -Fire, Explosion and Chemical Spillage
- Access to Records
- Rehabilitation
- Consequence analysis for new chemicals shall be included together with their emergency control procedures if different from existing.
- Specific medical treatment as per MSDS shall be noted by FMO and added in OHC manual and given training to first-aiders.

Annexures of onsite emergency plan to be revised accordingly.

Offsite Emergency Preparedness – already addressed in existing plan